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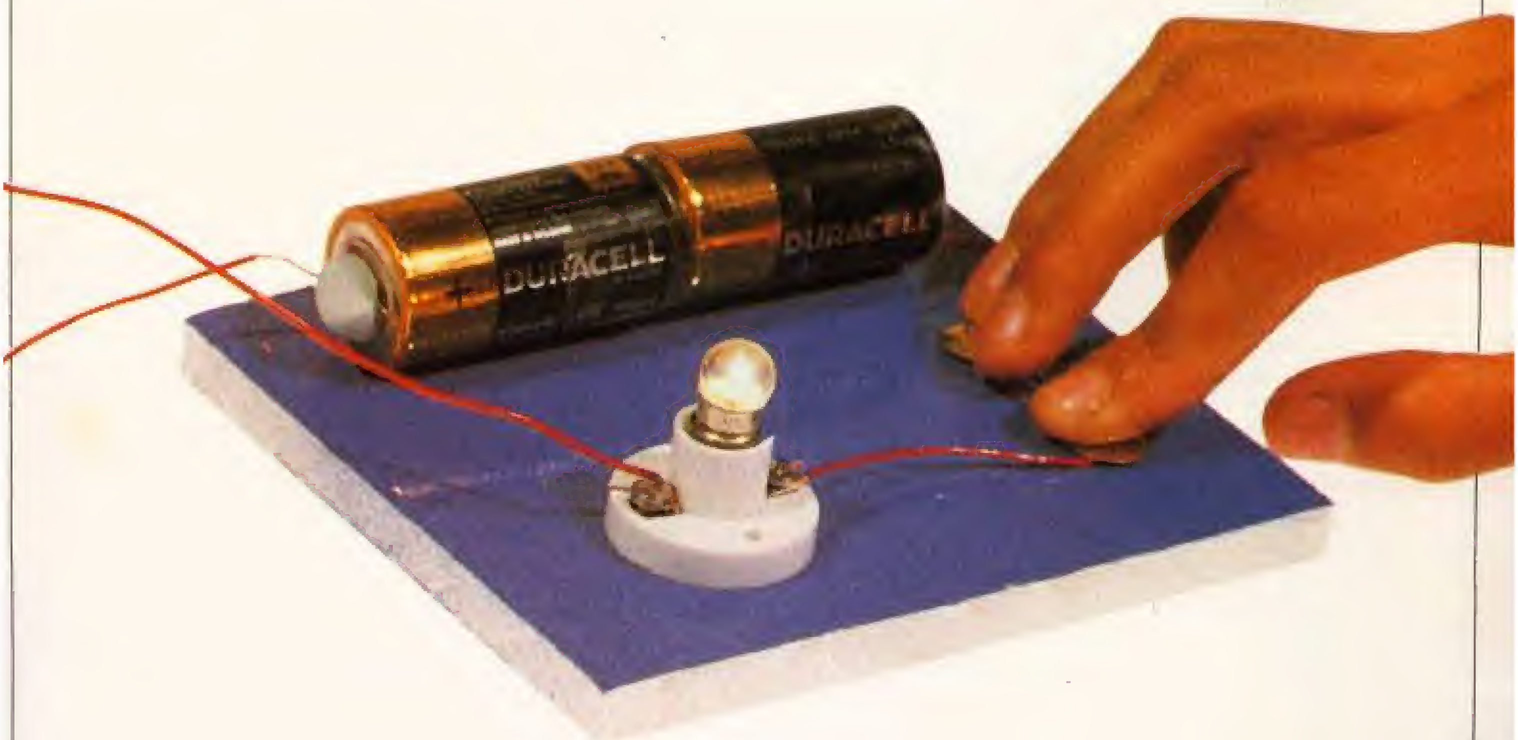
ELECTRICITY



Pam Robson

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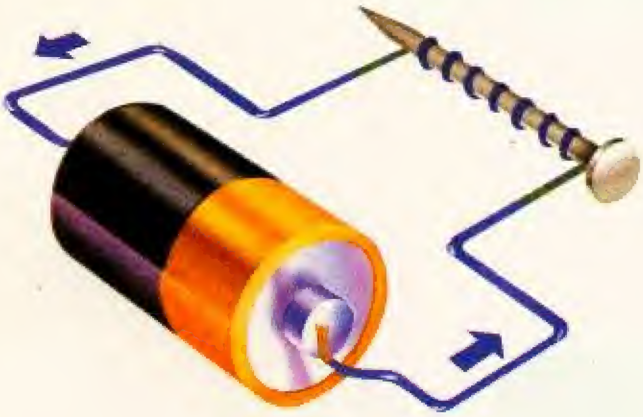

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Introduction

Electricity, natural and generated, influences every aspect of our lives. Electricity makes our bodies work as electric currents carry messages along nerves inside us. Some animals, like an electric fish, generate a strong electric current to ward off enemies. Electricity can be converted into heat and light, it can magnetize iron and it can be transformed into mechanical energy. So many things we do today are made easier by electricity. It enables us to cook, wash and clean without effort, it runs the machines that give us comfort and the trains we travel in. It even allows us to communicate across the world instantaneously. Electrical equipments fill almost every home. Soon we will see a computer that can store X-rays, a compact disc that can record videos, and even a videophone. Yet, there are still parts of the world where electricity is non-existent or its supply is minimal or irregular. Areas that do not receive mains electricity may rely on wind, water or solar power. These sources of energy may be used more extensively in the future. For although electricity is clean to use, it is usually generated by fuels that are not.

THE LABORATORY

A science laboratory is a place to test ideas, perform experiments and make discoveries. To prove many scientific facts, you don't need a lot of fancy equipment. In fact, everything you need for a small laboratory can be found around your home or school. Read through these pages, and then use your imagination to add to your "home laboratory". Make sure that you are aware of relevant safety rules, and look after the environment. A science experiment involves the use of certain basic rules to test an hypothesis. A qualitative approach involves observation. A quantitative approach involves measurement. Remember, one of the keys to being a creative scientist is to keep experimenting. This means experimenting with equipment to give you the most accurate results as well as experimenting with ideas. In this way you will build up your own laboratory as you go along.

MAKING THE MODELS

Before you begin, read through all the steps. Then make a list of the things you need and collect them together. Next, think about the project so that you have a clear idea of what you are about to do. Finally, take your time in putting the pieces together. You will find that your projects work best if you wait while glue or paint dries. If something goes wrong, retrace your steps. And, if you can't fix it, start all over again. Every scientist makes mistakes, but the best ones know when to begin again!

GENERAL TIPS

There are at least two parts to every experiment: experimenting with materials and testing a science "fact". If you don't have all the materials, experiment with others instead. For example, if you can't find any polystyrene, use cardboard or balsa wood instead. Once you've finished experimenting, read your notes thoroughly, think about what happened, and evaluate your measurements and observations. What conclusions can you draw from your results?

Safety Warnings

Make sure that an adult knows what you are doing at all times. Cutting and bending a coat-hanger, for example, can be dangerous. Ask an adult to do this for you. In the experiments that use electricity, always use a battery of 1.5 volts. Never use mains electricity! Always make sure that your hands are dry. Electric current may pass through water and give you a strong jerk. Always be careful with scissors. If you spill any water, wipe it up right away. Clean up your laboratory when you finish!

Experimenting

Always conduct a "fair test". This means changing one thing at a time in each stage of an experiment. In this way you can always tell which change caused a different result. As you go along, record what you see and compare it to your earlier thought about what would happen. Ask questions such as "why?", "how?" and "what if?". Then test your model and write down the answers.

Natural Electricity

Thousands of years ago the Greeks noticed that a type of stone, called amber, attracted light objects, like feathers, after it was rubbed. The Greek word for amber is elektron. Some materials, such as plastic, do not let electricity pass through, but if they rub against another material, a charge of static electricity can be produced. (Static means staying in the same place.) We experience it daily–you may hear a crackling sound when you take off your jumper. Sometimes a spark is produced. Rubbing or friction causes static electricity. You can generate your own static electricity and watch the frogs jump.

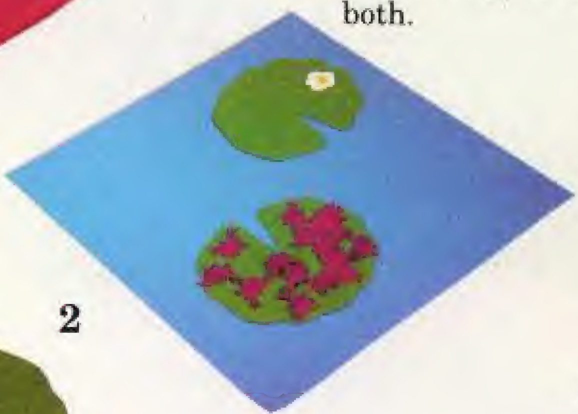
Active Amphibians!

1. Fold a piece of tissue paper a number of times and cut out the shape of a frog. This way you can cut out several frogs at the same time.

1

3

3. Cut a bird shape out of a yellow card. Attach it to the table tennis ball by threading a string through both.



4. Tie the other end of the string to the end of the stick. Make sure that the bird rests on top of the ball.

2. Cut out two lily pad shapes from a green card. Cut out some flowers too. Put the lily pads on the card. Place the frogs on one lily pad.

2

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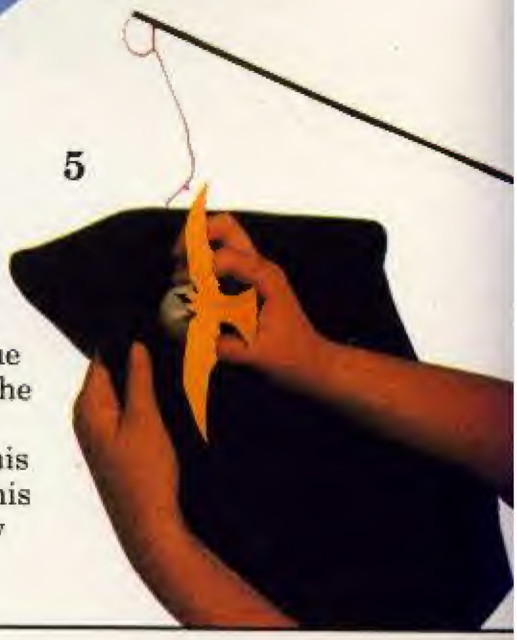


5. A short distance away from the tissue paper shapes, rub the ball against the woollen cloth. Do this quite vigorously. This produces negatively charge on the ball.

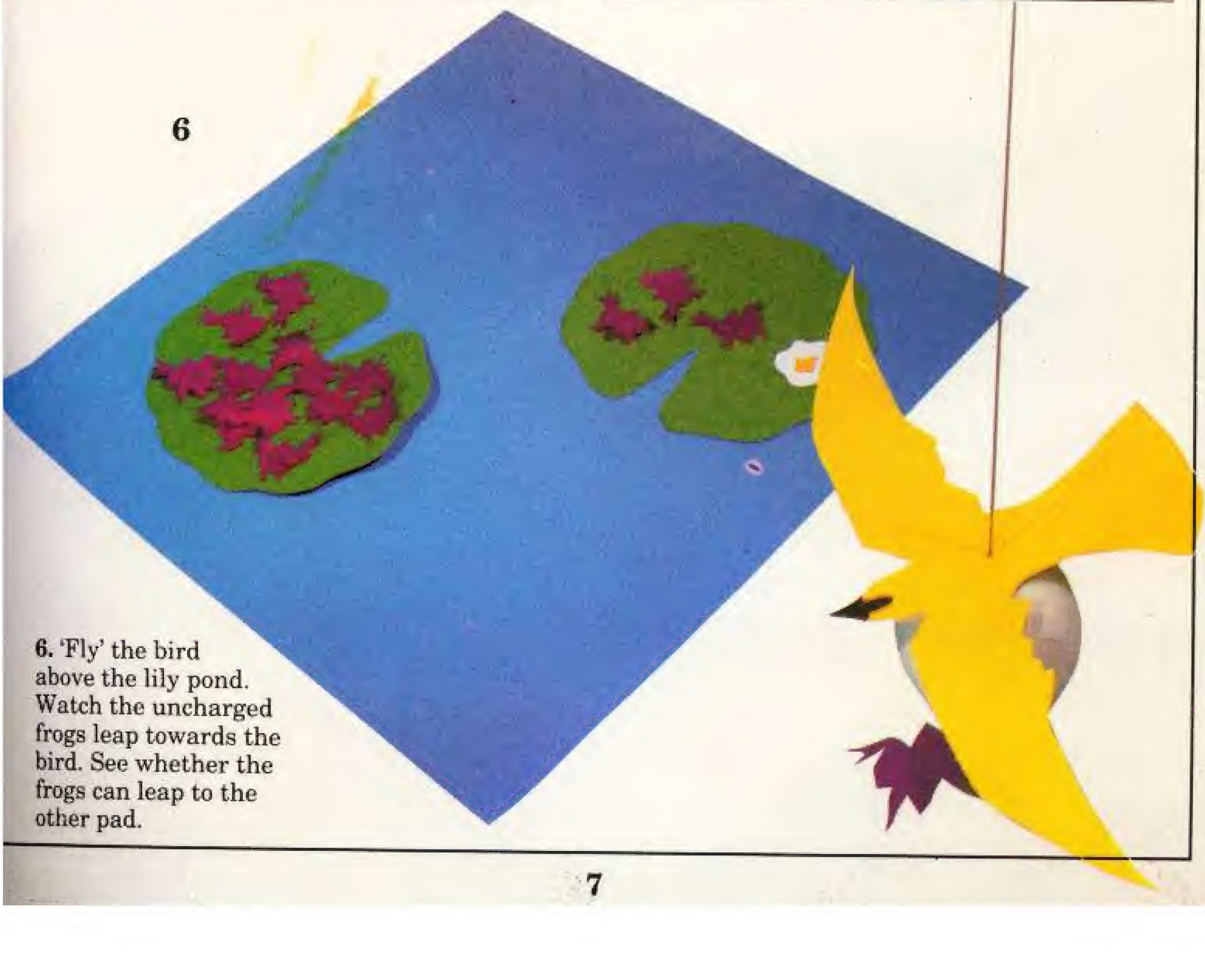
Why It Works

All materials are made up of atoms that are electrically neutral. However, if atoms gain tiny particles called electrons, they become negatively charged. If they lose electrons, they become positively charged. Like charges repel each other, while unlike charges attract each other. When the table tennis ball is rubbed on the woollen cloth, it gains electrons and becomes negatively charged. The tissue paper frogs, which are not charged, jump towards the ball when it is close by. Each time the frogs jump, they are charged in a process called induction.

Bright Ideas

Rub a balloon on woolen material, then hold it against a door. Now let go off the balloon. What happens? How long does the effect of static electricity last?

Make a water bow. Rub a plastic spoon on wool. Hold the spoon near a stream of water from a tap. The water will bend towards the spoon. What happens if the water touches the spoon?



6

6. 'Fly' the bird above the lily pond. Watch the uncharged frogs leap towards the bird. See whether the frogs can leap to the other pad.

THUNDER & LIGHTNING

The nature's most spectacular display of static electricity is a flash of lightning. People of ancient civilizations believed that thunder and lightning indicated the anger of their gods. During a thunderstorm, raindrops and hailstones hurl up and down inside a thunder cloud producing charges of static electricity. Positive charges move to the top of the cloud, negative charges to the bottom. The Earth is positively charged, so the negative charges in the clouds are attracted downwards. This is why lightning occasionally strikes the Earth. The hottest part of lightning can reach a temperature six times that on the surface of the Sun. You can make sparks like flashes of lightning that are not dangerous at all!

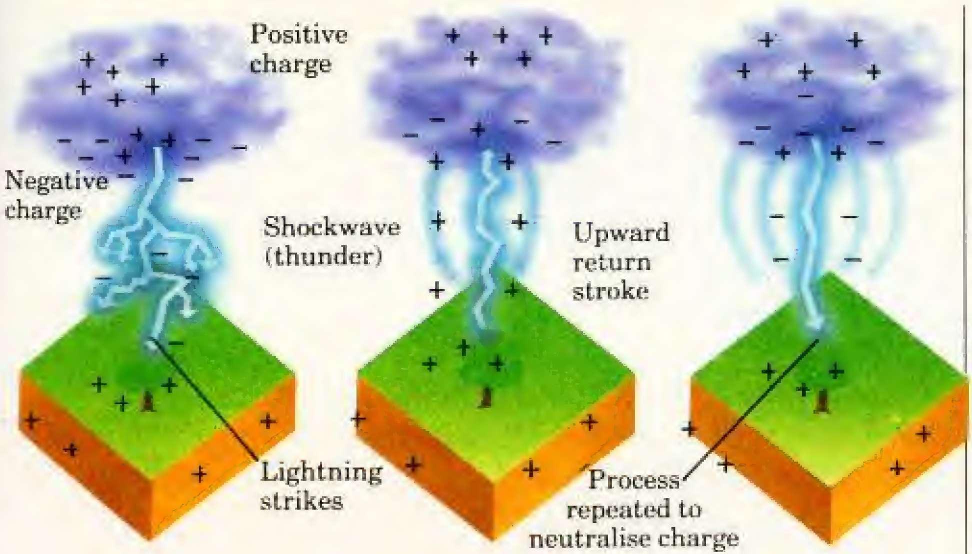
LIGHTNING FLASHES

1. You will need a large plastic bag, a metal tray, plasticine and a metal fork or skewer. It is best to do the experiment on a floor with a vinyl covering.

2. Stand the metal tray, centrally on top of the large plastic sheet. Put a piece of plasticine, large enough to use as a 'handle' in the centre of the tray. Make sure that it is firmly fixed to the tray.

3. Grip the plasticine with one hand. Press down firmly and rotate the tray vigorously on the plastic sheet. Do this for at least a minute. Using the plasticine as a handle, lift the tray off the plastic and keep it suspended in the air.

2



Why It Works

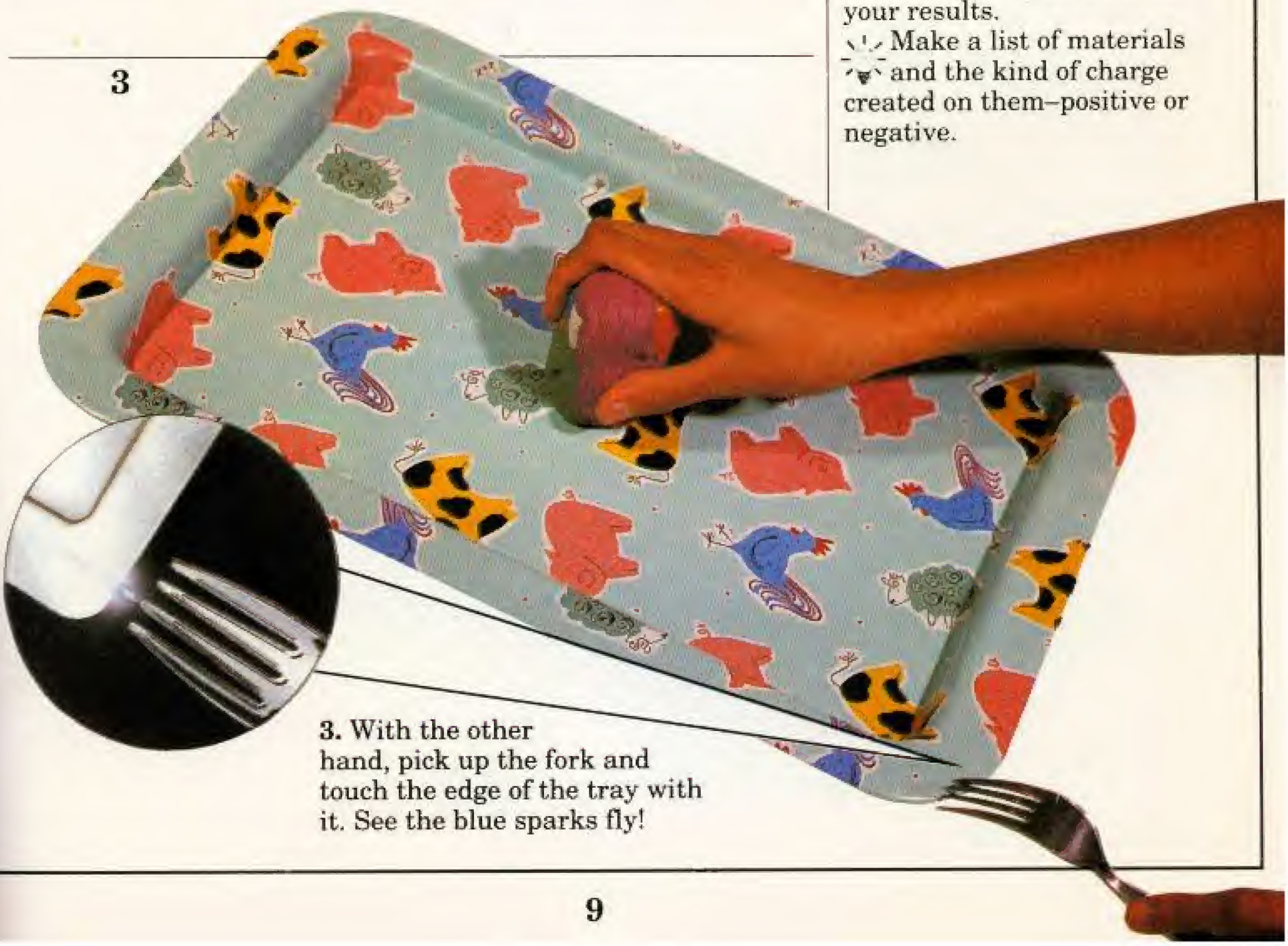
Although electricity can pass through the metal tray, it cannot pass through the plastic. As the tray is rubbed on the plastic, it becomes negatively charged. When the positively charged metal fork is brought close to the tray, the negative charges are attracted to the positive. They pass from the tray to the fork as a blue spark. This is how lightning works.

Bright Ideas

Rub other materials together. Which become positively charged and which negatively charged? Do they repel or attract each other? Rub a strip of paper with a woollen cloth. Then hang it over a ruler. The ends of the paper will repel each other because they are similarly charged. Rub a plastic pen with the cloth then hold the pen between the ends of the paper. It will attract the paper, pulling the ends together, because plastic has a strong negative charge. (A moving plastic conveyor belt in a factory can create strong static electricity, and static eliminators have to be used to neutralize the charge.) Try using other materials. Keep a record of your results.

Make a list of materials and the kind of charge created on them–positive or negative.

3



3. With the other hand, pick up the fork and touch the edge of the tray with it. See the blue sparks fly!

A Simple Circuit

Due to the scientific experiments about electricity and magnetism carried out by men like William Faraday, it is now possible to make large amounts of electricity. It can be carried along wires to our homes, like water in a pipe, from a power station. Then it is turned into light, heat and mechanical energy. Every time you switch on a light you are completing a pathway for the electricity, called a circuit. This allows the current to flow through electrical appliances. It was not until the 1950s that most homes were finally wired up to receive electricity. Yet, there are still some areas of the world that have no electricity at all. Our homes receive power from mains electricity (see page 24). Do not try to use mains electricity for the projects in this book–it is dangerous. Using a battery, you can set up a game which needs only a simple, safe electric circuit.

A Game Of Nerves!

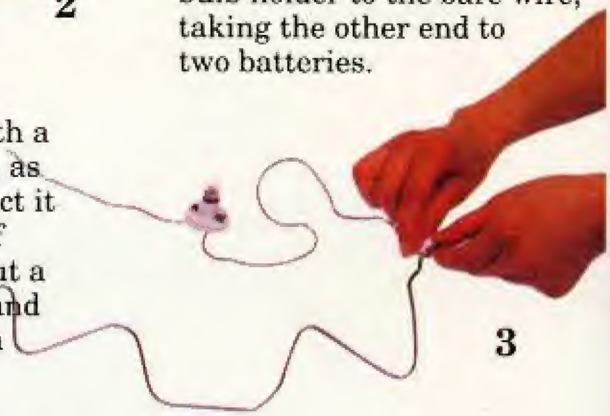
1

1. You will need a small 6 volt bulb in a bulb holder. You can buy one of these from an electrical shop. Attach two lengths of insulated wire on either side.

2

2. Form a loop with a piece of thin wire, as shown, and connect it to a long length of insulated wire. Put a plastic straw around the joint to form a handle.

3. Now ask an adult to open up a wire coat hanger and bend it into bumps and curves. Attach one side of the bulb holder to the bare wire, taking the other end to two batteries.



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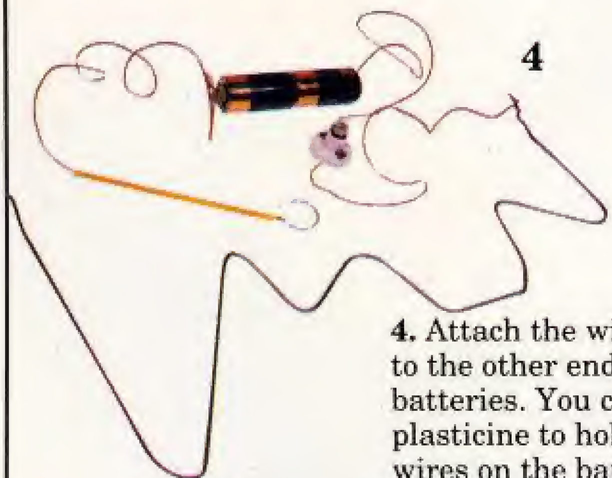

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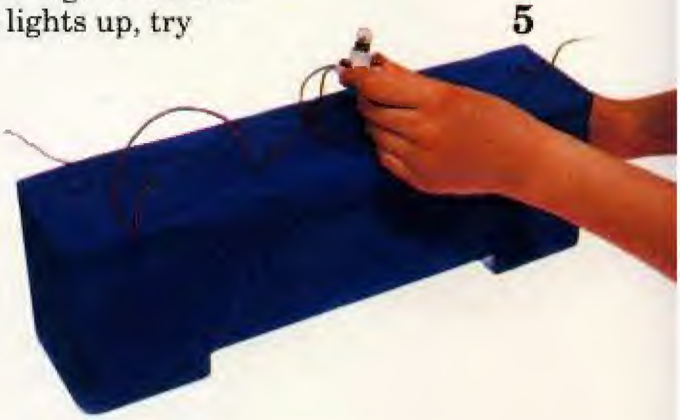
4. Attach the wire loop to the other end of the batteries. You can use plasticine to hold the wires on the battery terminals.

5. Hide the batteries inside a piece of polystyrene and stand the bent wire on the top. Pass the loop along the wire. If the bulb lights up, try again.



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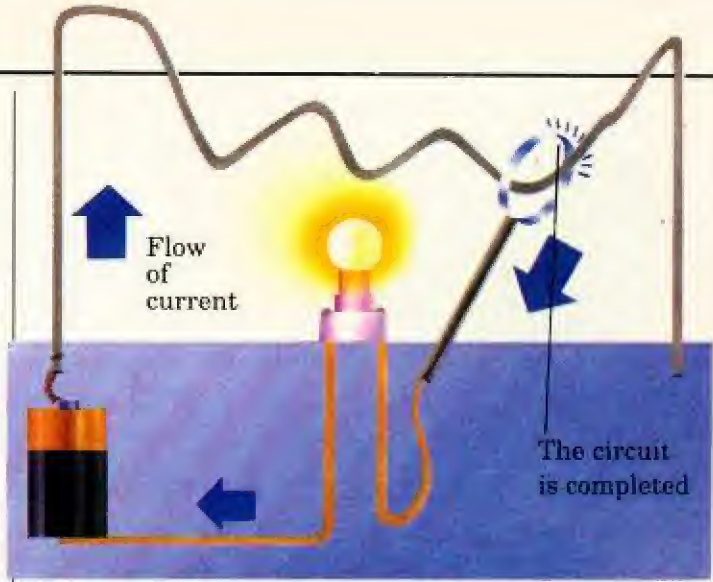
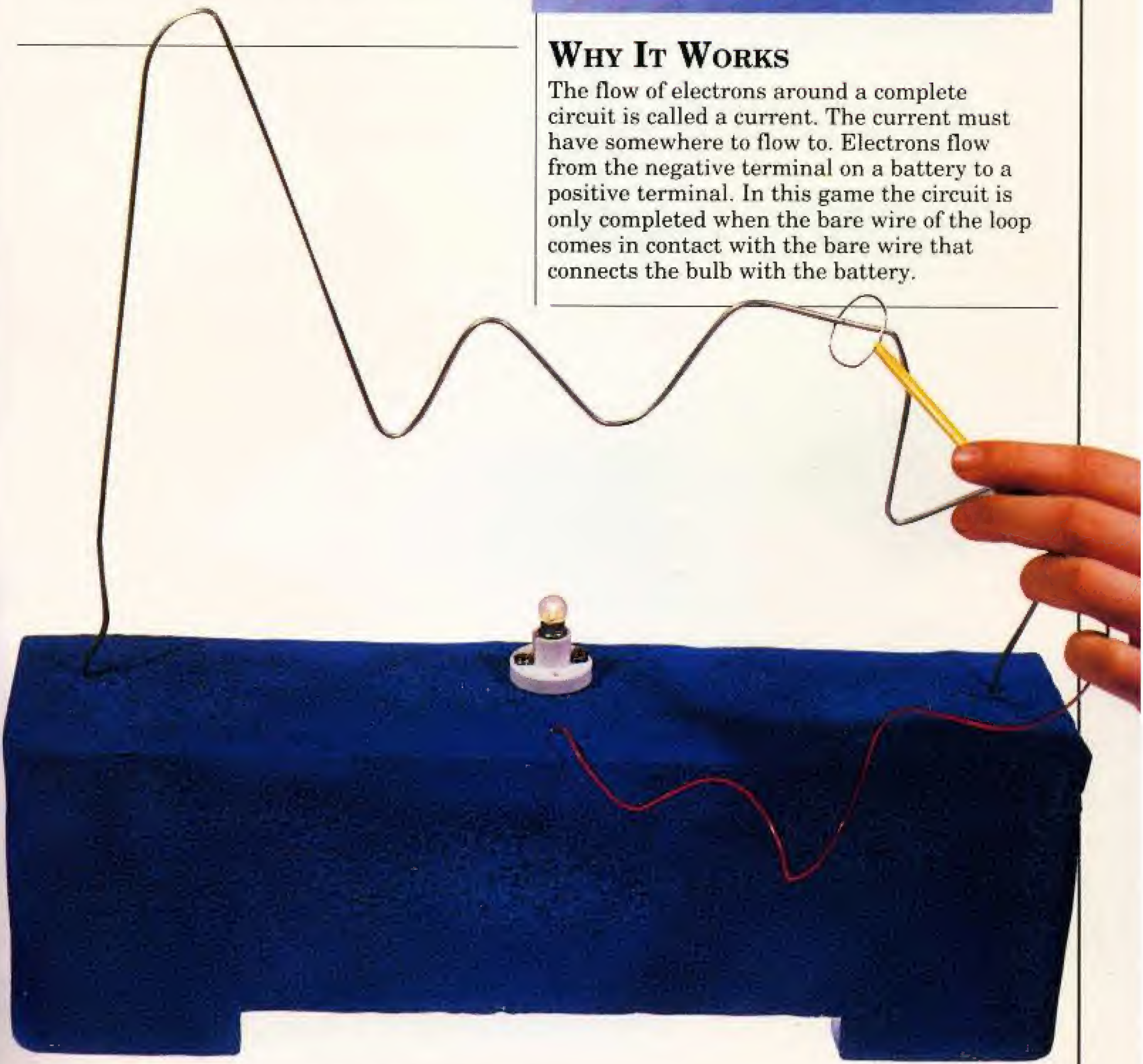
Bright Ideas

- Make the game more difficult by making the wire loop smaller. Extend the length of the circuit by using a longer piece of wire. Now you can put in more curves or bends.
- Demonstrate how a short circuit can happen by setting up a simple closed circuit using bare wire. Lay a metal conductor, such as a screwdriver, across both wires. The light will go off.
- Add another battery. What do you notice? How long does the bulb last?



Why It Works

The flow of electrons around a complete circuit is called a current. The current must have somewhere to flow to. Electrons flow from the negative terminal on a battery to a positive terminal. In this game the circuit is only completed when the bare wire of the loop comes in contact with the bare wire that connects the bulb with the battery.



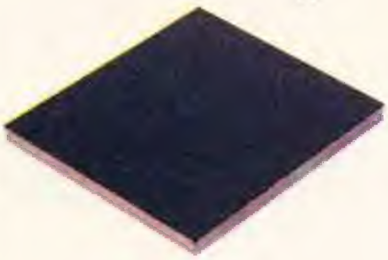
Open Circuits

In an open circuit the flow of electricity is controlled by a switch, the simplest way of controlling the flow of current. When the switch is open, or off, it creates a gap in the circuit. When the switch is closed, or on, the electricity can flow. Telegraphy is the transmission of electric signals. After it was invented in 1838, it allowed people to communicate directly with each other over long distances. In the same year Samuel Morse introduced his Morse Code–a dot and dash code of short and long electrical signals. These were passed along the wire and decoded at the other end. In 1910, telegraphy was used for the first time to capture a notorious murderer, called Dr. Crippen. The international Morse Code distress signal has always been S.O.S.–three short, three long, three short flashes. But soon the ships in distress will transmit a unique identification number via satellite instead.

S.O.S.

1. You will need two sheets of polystyrene, plasticine, two light bulbs and holders, four 1.5 volt batteries, 6 short lengths of insulated wire, 4 drawing pins and 2 paper clips.

1

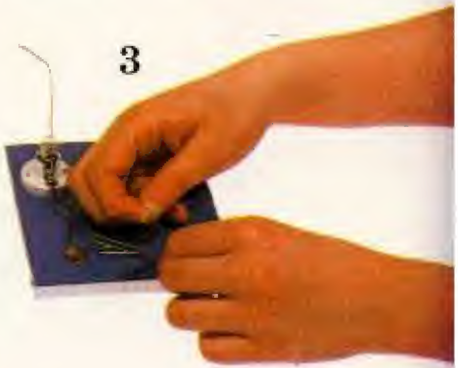


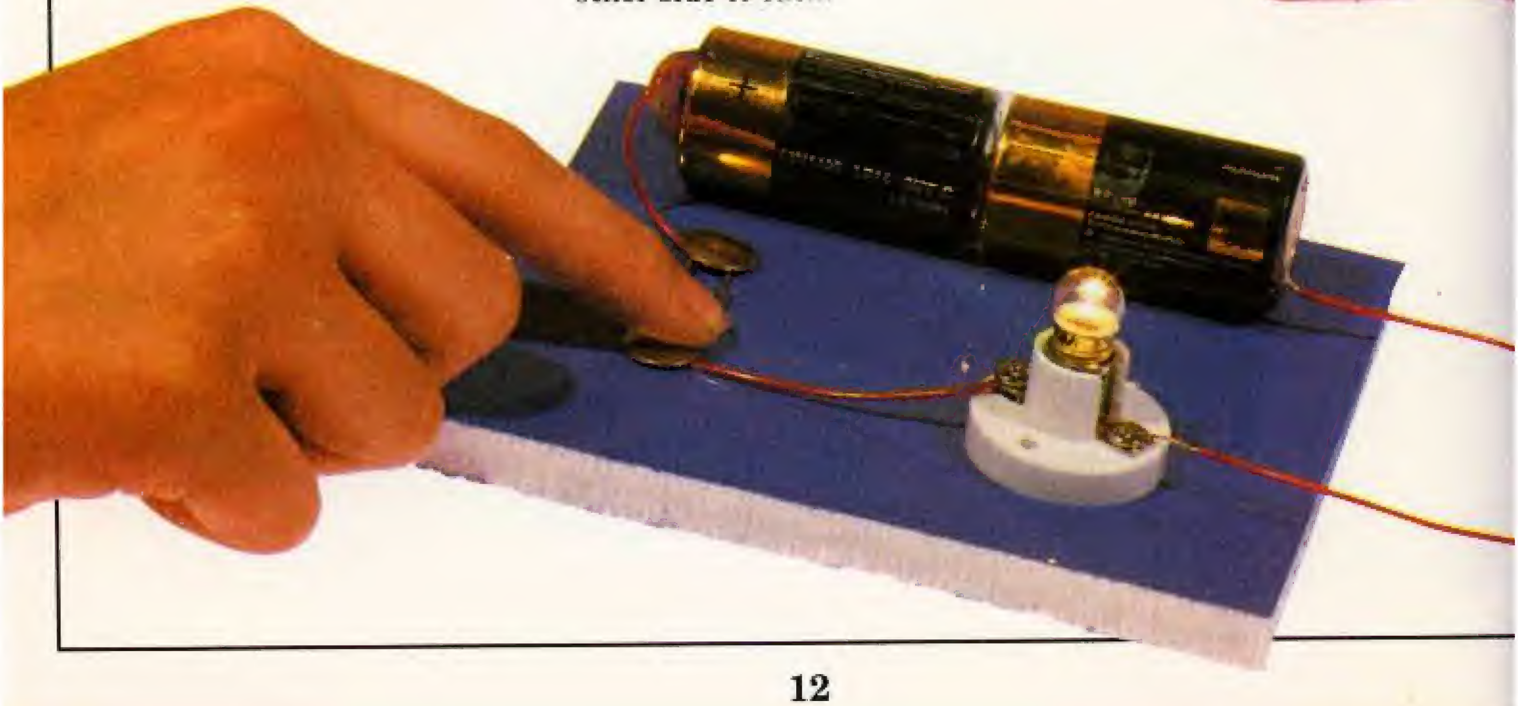
2

2. Place a bulb in each bulbholder and stand on the polystyrene boards. Connect the two bulbholders and attach wires to the other side of each.

3. Use the drawing pins and paper clips to make a switch for each board. Connect the loose wires to the drawing pins, connecting a paper clip to one of them.

3

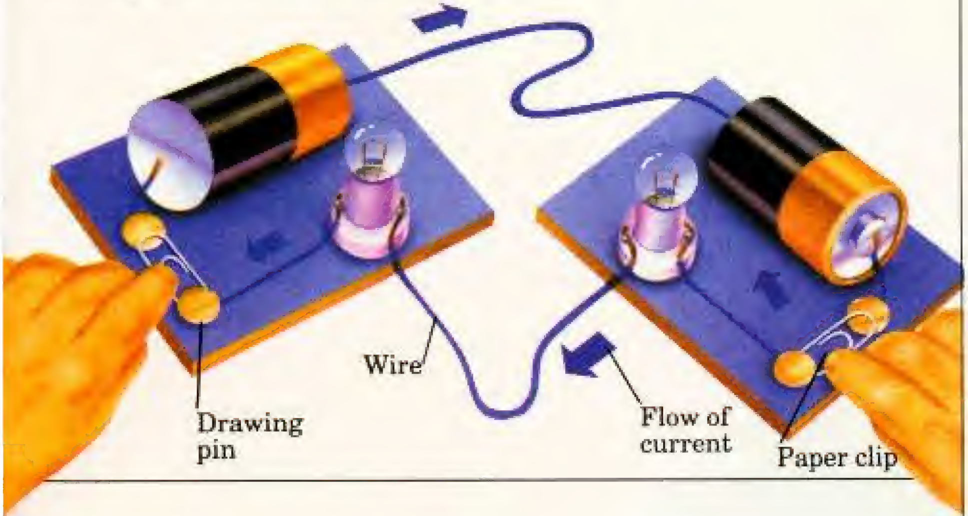




Why It Works

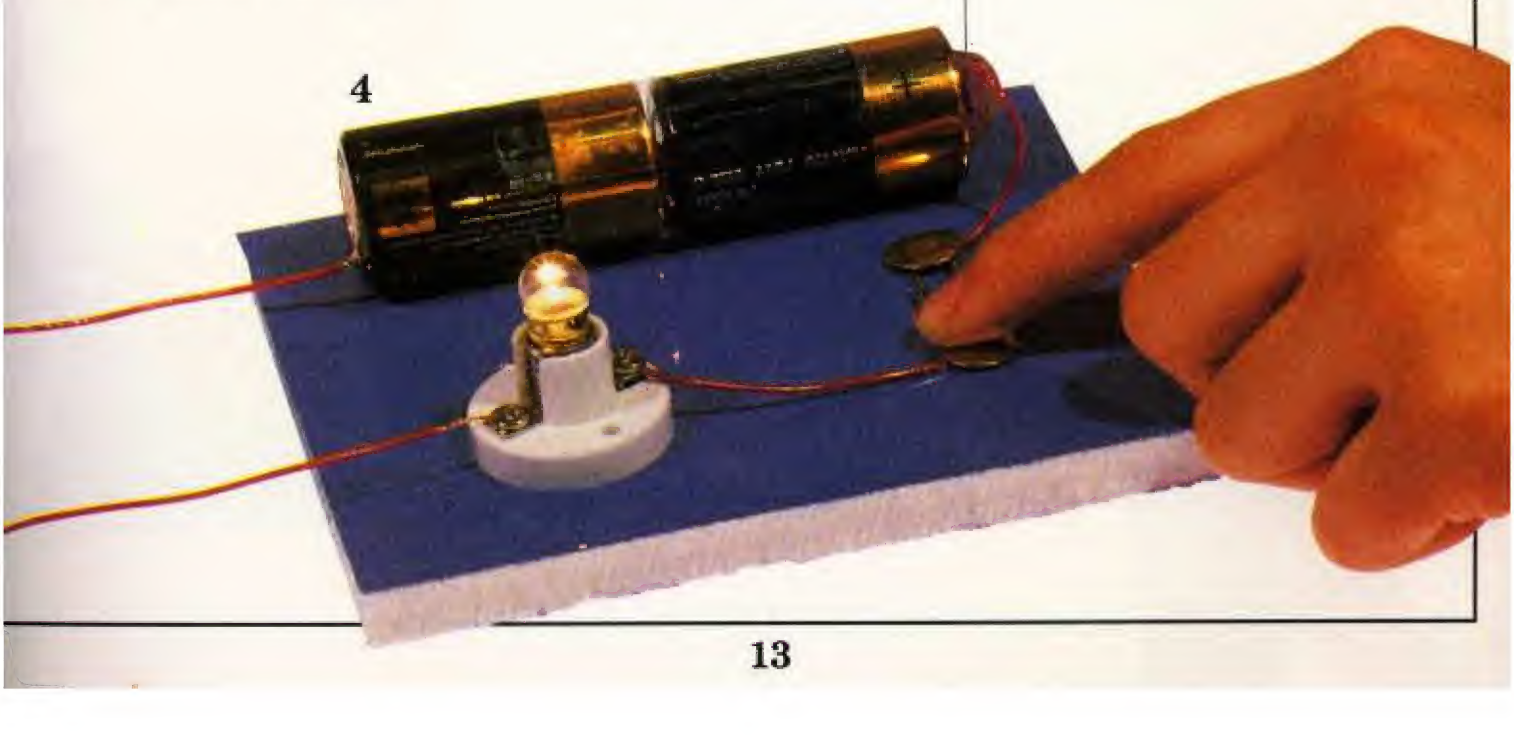
The paper clips act as switches. Both must be in contact with the drawing pins to allow electrons to flow round the whole circuit and light up the bulbs. The sender must raise one paper clip to turn the bulb on and off–the receiver must keep the other down to complete the circuit.

A mechanical switch in the home is slow to work and produces a spark. It joins and separates electrical contacts in the circuit. The spark produced creates high temperatures. A relay is an electrically controlled switch; it can be operated by various means, but the most common is an electromagnet called a solenoid (see page 28). The solenoid uses an electromagnet to move a metal rod through a short distance. This opens or closes the relay circuit.



4. Rest two batteries end to end on each board and connect them into the circuit using plasticine. Check whether the bulbs work, by holding down both clips.

5. The bulbs are connected in series. When one bulb lights, both light. Make a gap in the circuit, and the bulbs will not glow.



Bright Ideas

S.O.S. is 3 short, 3 long, 3 short flashes–now try sending a whole message. Find a copy of the Morse Code. Can you 'translate' a reply? Can you build a two-way circuit that will work from another room. If you use bulbs, the wiring must be long enough to link the two. What happens to the light from the bulb if you use longer wire? How can you tell when each word and sentence ends? Try working out a special code, then you can send secret messages.

Make a burglar alarm system with a pressure switch made out of folded aluminium foil. Hide the switch underneath a rug and connect it into an electrical circuit with a buzzer or bulb. Which kind of alarm is most effective–a bulb or buzzer?

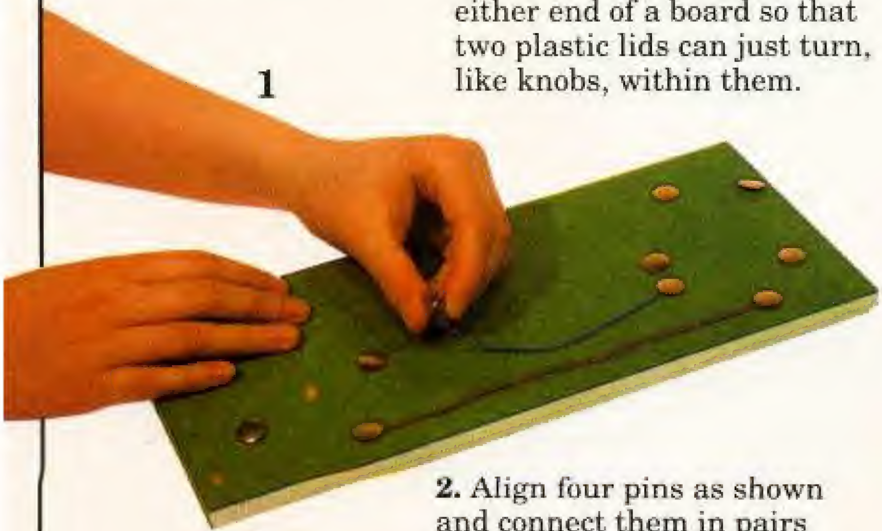
How many switches are there in your home? Where are they? What does each switch operate? Carry out a survey.

Switches & Energy

Most modern gadgets, such as kettles and toasters, switch off automatically. This is not only important to conserve energy, it is a safety precaution too. Heating appliances, such as cookers and irons, have thermostats fitted so that a particular temperature can be maintained–an internal switch turns the heater on or off as required. Because most of our electricity is generated from sources of energy like coal which will run out, we must be aware of the need to save energy whenever possible. The two-way switch is important today, both as a safety device and as a means of conserving energy. If a light can be switched on or off from the top or the bottom of a staircase, not only is it safer at night, but light energy is saved as well. Make your own two-way switch and discover how it works.

Switch Off!

1



1. Position drawing pins at either end of a board so that two plastic lids can just turn, like knobs, within them.

3. Connect one wire to a paper clip inserted through the lid, as shown. Take the other to the batteries.

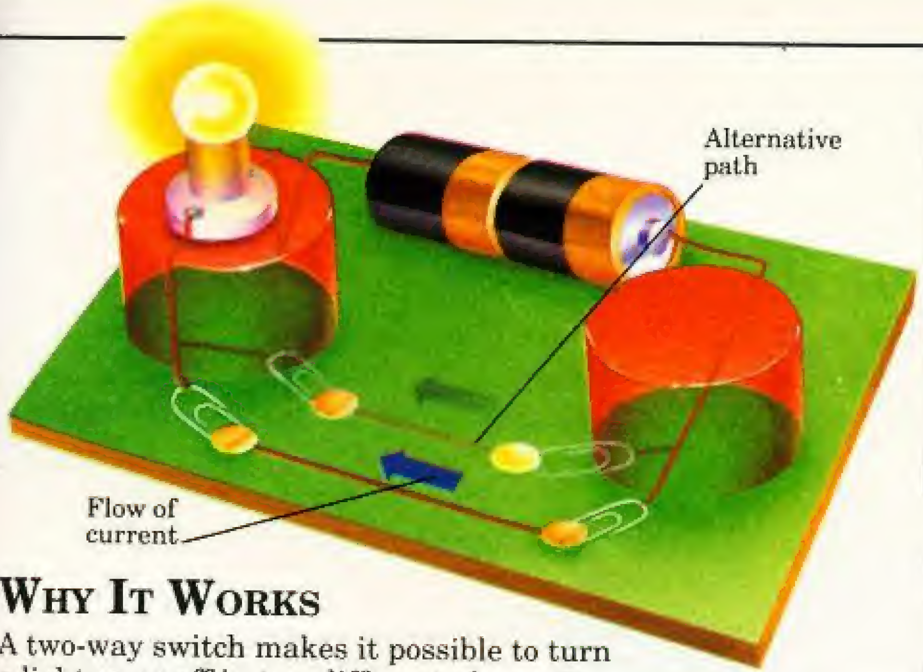
3

2. Align four pins as shown and connect them in pairs with two lengths of wire. Make a hole in the top of one plastic knob and insert the two wires connected to a bulbholder.

2

4. Form a switch at the other lid in the same way, connecting the wire to the batteries. Plasticine will hold the wires in place.

4



Why It Works

A two-way switch makes it possible to turn a light on or off in two different places. In order for this to work, an alternative pathway for the electricity must be built into the circuit. For the electricity to flow along the blue or red wires, both ends must be connected to the battery at the same time. If the bulb is switched off by moving the paper clip from blue to red at one end, then it can be turned back on by changing from blue to red at the other end.

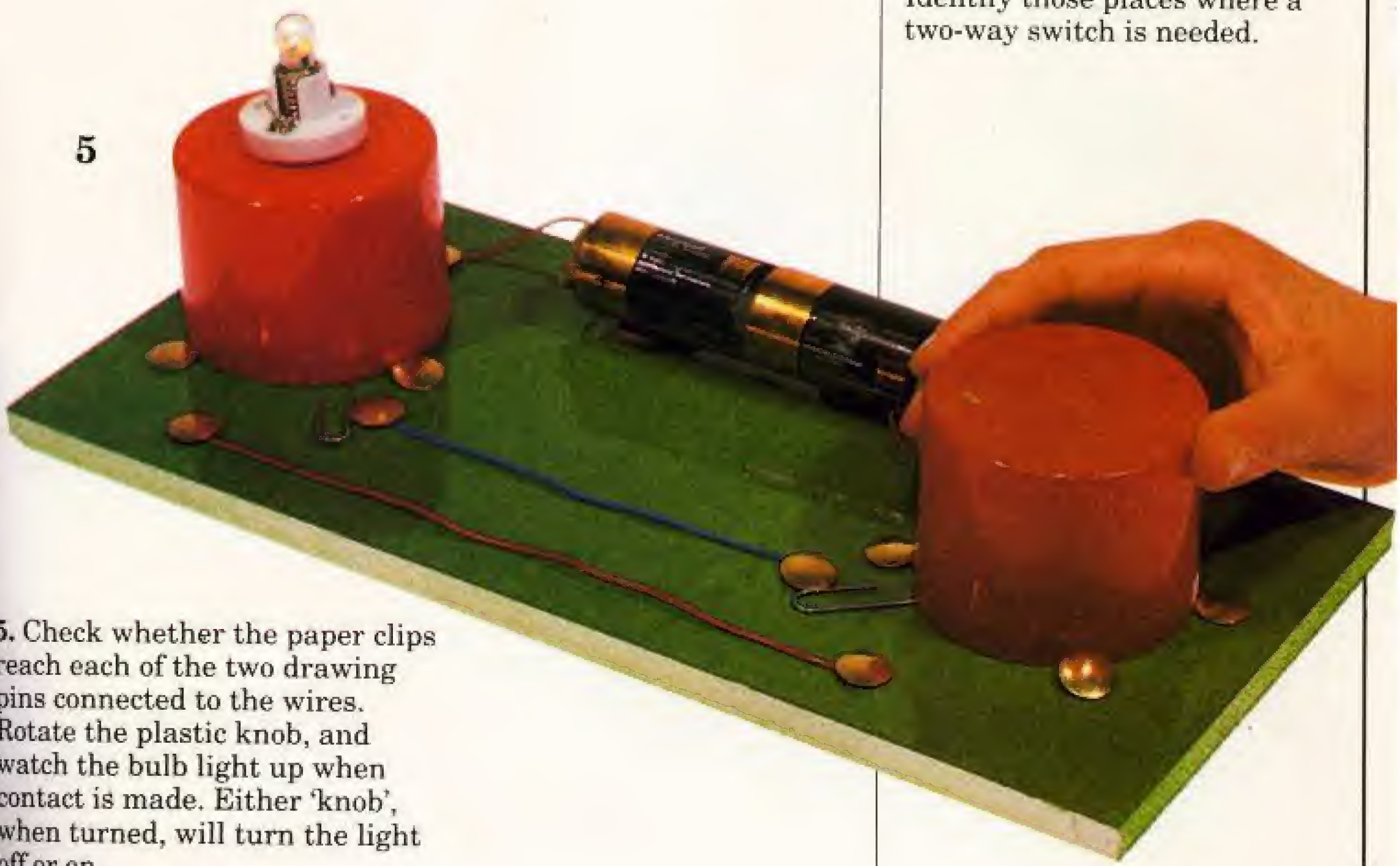
Bright Ideas

A person in a wheelchair may need a light switch to be lower down. Design a two-way switch circuit to satisfy this need.

Build a two-way switch circuit and incorporate it into a model staircase made of card. Remember that you must incorporate an alternative circuit so that each switch works in two directions. If you increase the distance between the two switches, does it have any effect on the light produced? Do you need an extra battery? Now, shorten the distance. Are there any changes?

Find out how many two-way switches there are in your home or school. Make a record of where they are. Why are they positioned like that? Identify those places where a two-way switch is needed.

5



5. Check whether the paper clips reach each of the two drawing pins connected to the wires. Rotate the plastic knob, and watch the bulb light up when contact is made. Either 'knob', when turned, will turn the light off or on.

Bulbs

The warning flashes from lighthouses are vital to the safety of ships around the coastline. It was not until the mid-nineteenth century that lighthouses were fitted with electric light bulbs. Two men were responsible for the invention of the incandescent (white-hot) electric light bulb–Joseph Swan, an American, and Thomas Edison, an Englishman. Edison's light bulbs contained a carbon filament within a vacuum. He first produced this on 21st October, 1879. By 1913, the tungsten filament (a type of metal), that is still used today, had been introduced. Neon lights, like those shown here, contain a gas. When electricity is passed through the gas, the tube glows. Electronic bulbs have also been developed. These produce only light–not heat–and so save energy.

Danger At Sea!

1

1. Take a piece of candle and make a hole down the centre. Use a paper clip to thread an elastic band through.

2

2. Push the candle into a cotton reel and fix the band to the top with sellotape. Also attach a bulb in a holder to the top passing the wires down through the candle.

3. Use a long cardboard tube for your lighthouse. Cut a piece of polystyrene to fit the end and fix the candle through the middle, as shown.

3

6. Line a plastic cup with aluminium foil. Cut out a window to see the bulb. A piece of card, with a hole to fit over the bulb, will hold it in place.

4. Insert the whole thing into the top of your lighthouse, allowing the wires to hang out of the end.

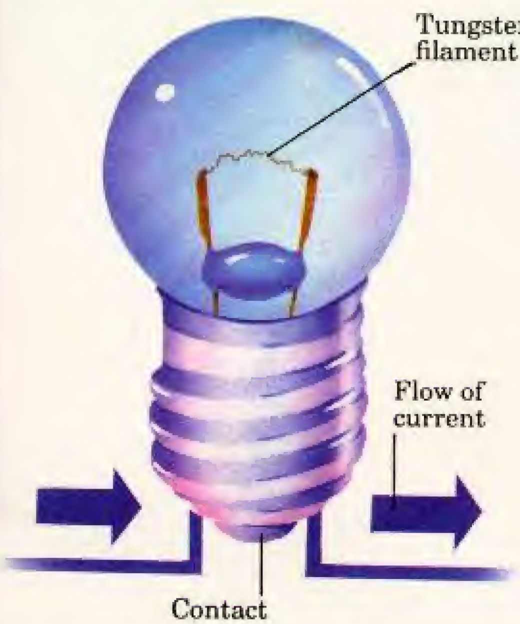
4

5. Fix the polystyrene, candle and elastic band in place with two cocktail sticks. Push them right through the cardboard tube, from one side to the other.

5

Why It Works

In a bulb the electrons travel through a very long, thin wire called the filament. By this process, electric energy is transferred into light energy. Tungsten is a highly resistant metal that can become white hot without melting. Within the bulb, air is removed and replaced by a harmless gas, argon. Electrons flow into the bulb when the circuit is complete and cause the wire to glow. Metal at the base of the bulb makes the required contact with the circuit. Bulbs can become very hot when switched on.



Bright Ideas

Can you make a different kind of flash light without switching the current off and on? Adapt the project to make the light revolve and flash in a different way. Try using coloured cellophane in the window to make a coloured light. Another way to make a flash light is to use a circle of card, out of which slits like the spokes of a wheel have been cut. Place it in front of the bulb, then revolve the card when the bulb is glowing.

Design and build a traffic light circuit so that the bulbs can be switched on and off in particular sequence. The sequence of change is different in various countries.

What causes a fluorescent strip light to flicker? The answer is to do with the fact that mains electricity uses an alternative current (a current that varies all the time).

Design a poster encouraging people to turn lights off and save energy.

7

7. Connect the wires to a battery and hide it under a pulp-made "rock". Add cotton wool for waves. Now twist the cotton reel around several times, let it go and watch the warning light turn.

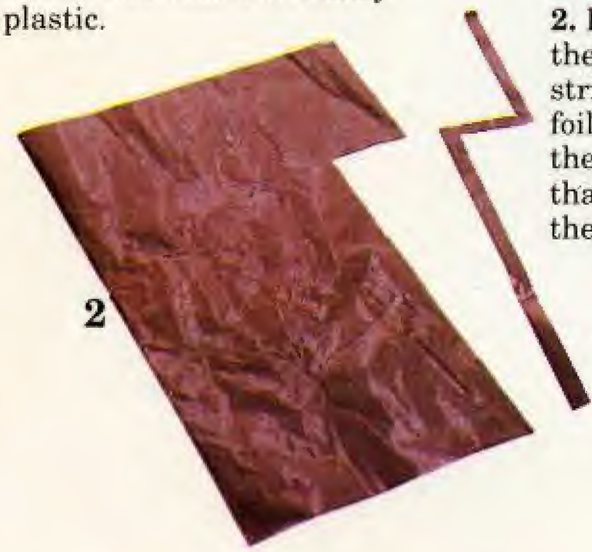
Insulators & Conductors

Our bodies can conduct electricity, especially when they are wet. Never touch plugs, points or light switches with wet hands. A conductor allows electricity to pass through it. We use conductors to take electricity to where it is needed. On the other hand, we use insulators to prevent it from reaching places where it could be dangerous. Both conductors and insulators have their own uses. Electricians, like the one shown here, wear rubber boots to protect them selves from electric shocks. Metal wires conducting electricity are insulated with rubber or plastic to make them safe. Conduct your way through a maze, using insulators and conductors as your guides.

Amazing!

1

1. Take a piece of thick board and cut out a piece of aluminium foil of the same size. Cover this with sticky plastic.



2

2. Design your maze on the board, and cut out strips of plastic-covered foil to fit the paths. Stick them down, making sure that your "pathway" is the last to go on.

3. Before you stick the final part of your "pathway" down, make a hole near the edge of the board and insert the end of some insulated wire.

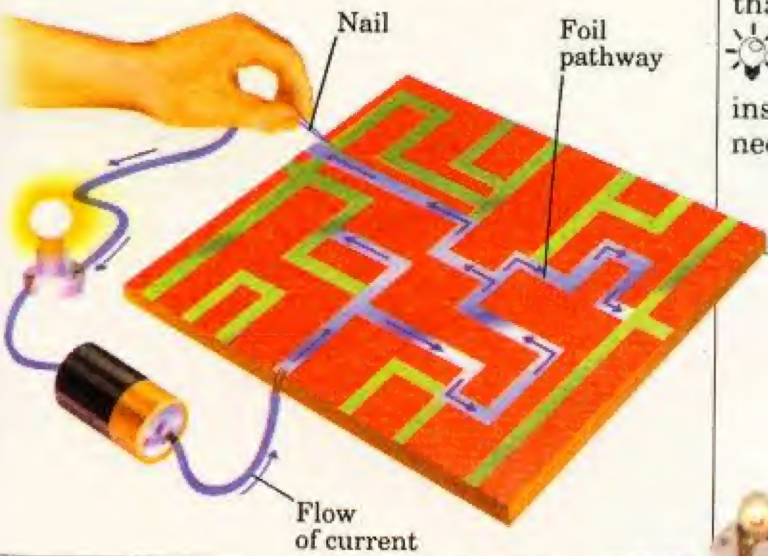
3

4. Attach this wire to one terminal of a battery. To the other terminal, attach more wire with a bulb holder in the middle. Connect the other end to a nail.

4

Why It Works

The aluminium foil conducts electricity and allows the circuit to be completed. Then the bulb glows. But when the nail touches the plastic covering in the maze, the bulb goes out. Plastic is an insulator. A substance that conducts electricity must contain charged particles that are free to move around. These free electrons move and make the current. The electrons in the plastic cannot move.



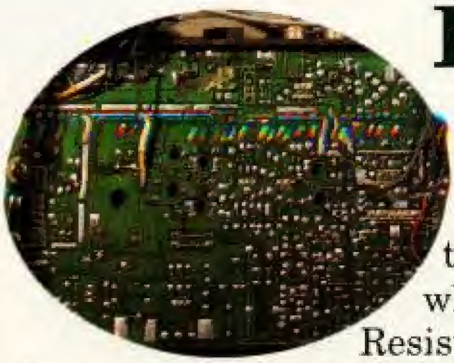
Bright Ideas

Build a simple circuit leaving a gap between two wires. Collect a variety of materials and, one by one, put each in the gap. Ensure that contact is made with the material by each of the bared wires. Which ones make the bulb light up? Record your results. Make separate lists. Which materials are insulators and which are conductors? Do some materials conduct electricity better than others? How can you tell?

Look at objects around you, such as tools and electrical equipment. Which have insulating material on them? Why is it necessary to insulate objects like this?

5

5. Find your way through the maze by watching the bulb. If it goes off, try another route.



ELECTRICAL RESISTANCE

James Watt, inventor of the steam engine was the person after whom the measurement of electrical power, the watt, was named. Electrical resistance is what makes the filament (long, very thin piece of wire) in a bulb glow when the element due to an electric flow becomes hot. Resistance is measured in ohms, after the German scientist, George Simon Ohm. Resistors are used in circuits, like the ones shown here. They are coils of wire, or poor conductors, built into the circuit to reduce the current. A variable resistor, or rheostat, is used to control the speed of a toy car and the volume of a radio or television. By building your own resistor, you can make a night light with a dimmer switch.

DIM THE LIGHT

1. Set up a circuit using a bulb in a holder, insulated wire, a board and safety pins. Ask an adult to take the lead out of a pencil, and cut out two pieces of thick card to rest it on.

4

4. To reflect the light, make a shade of cardboard and aluminium foil. Cut a slit in the flat disc and glue it into a cone shape.

1

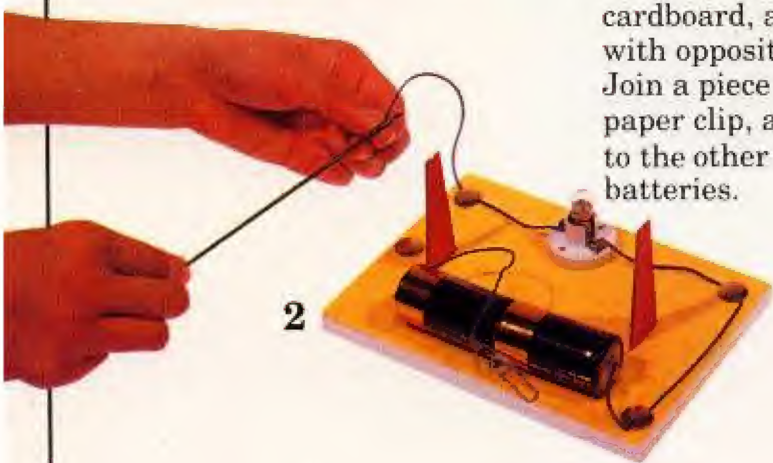
5

5. Cut a hole in the centre of the cone and place it over the bulb. Slip the paper clip over the pencil lead and watch the bulb light up.

2. Fix one end of the wire to the batteries and the other end to the pencil lead.

3. Rest the lead on the cardboard, and fix the batteries with opposite terminals together. Join a piece of wire to a paper clip, and fix it to the other end of the batteries.

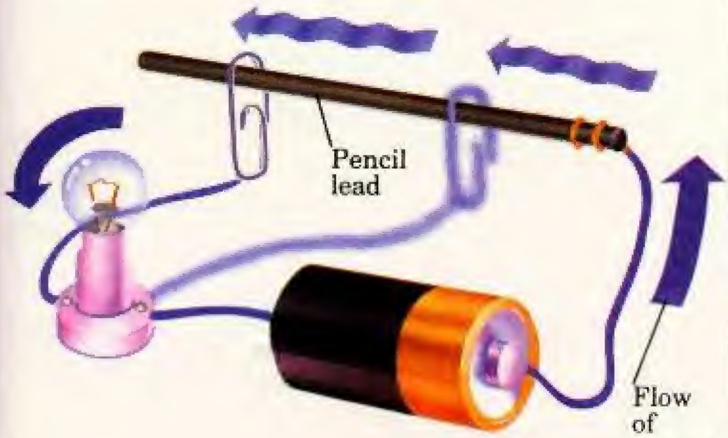
2



3

Why It Works

A pencil lead is made of graphite, which conducts electricity. All conductors have some resistance and the longer the conductor, the greater its resistance is. As the paper clip moves towards the battery, the electricity doesn't have to travel so far. The bulb therefore becomes brighter. As it is moved away from the battery, the light dims.



Bright Ideas

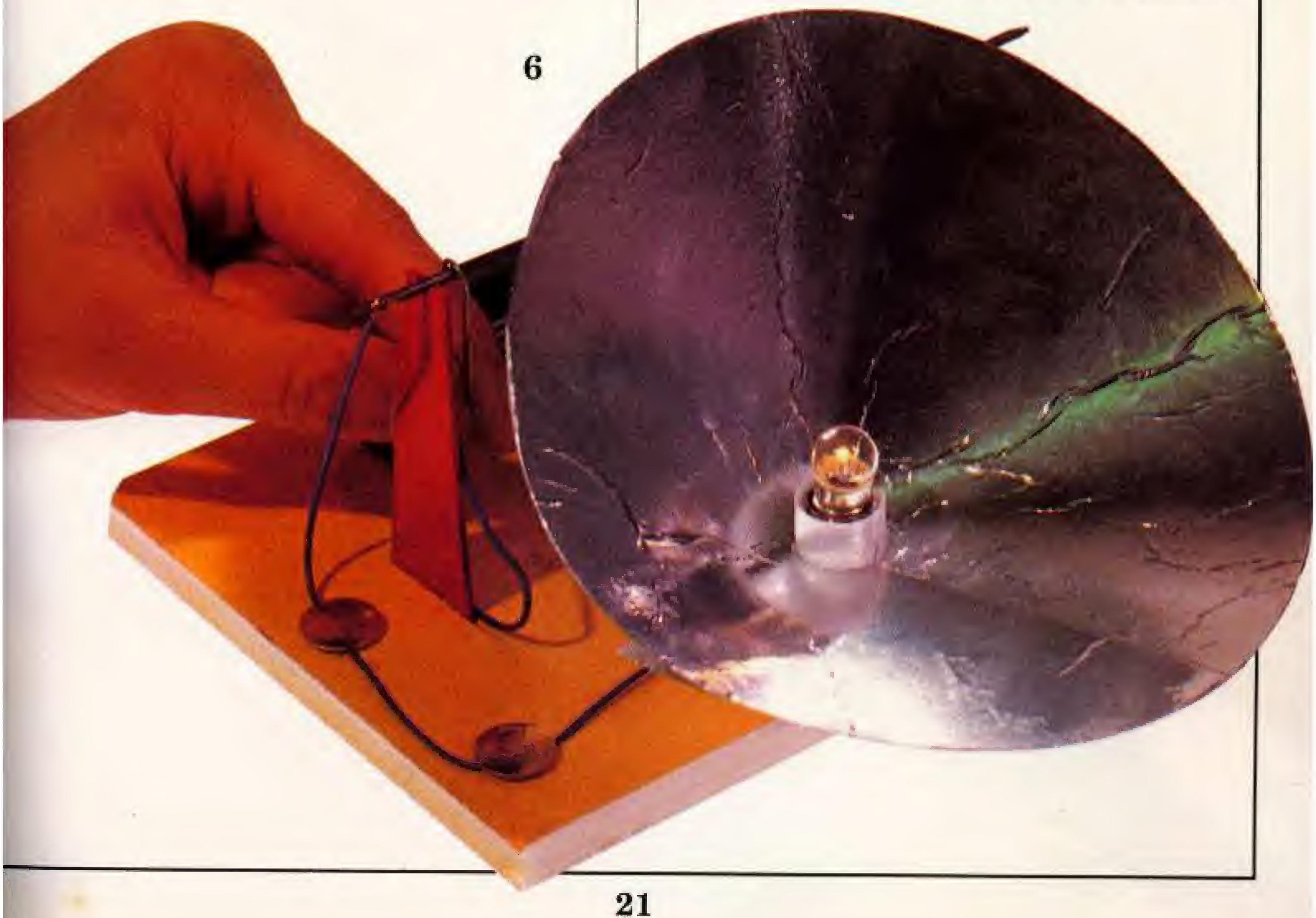
Repeat the project attaching the paper clip to the wire from the bulb. Attach the pencil lead to the wire from the battery. When is the bulb brightest? Which way must you move the paper clip to dim the light now? Which works best?

Build a model theatre set with a circuit of floor lights. Use coloured paper to create coloured lights. By building a variable resistor into the circuit, you can dim or brighten the stage lights.

You can make another kind of dimmer by immersing a length of aluminium foil in salt water while it is connected to a circuit. A second piece of foil, connected to the other end of the circuit, is at the bottom of the container. Watch what happens when you move the top piece of foil up and down in the water.

6. Move the paper clip up and down the pencil lead. The bulb would get brighter or dimmer.

6



Series & Parallels

As long ago as 1810, many larger cities had street lighting. An electric current was made to jump between two carbon rods–this was called electric arc lighting. First introduced by Sir Humphry Davy, these lamps were connected in series. This meant that all the lamps were connected as a part of one large circuit. It also meant that if one lamp went out, and the circuit was broken, they all went out. This often happens with Christmas tree lights. However, all lights can be arranged in parallel circuits to avoid this problem. It was Thomas Edison who suggested how to use parallel circuits for street lighting. Each bulb in a parallel circuit has a circuit of its own. If one bulb fails, the others will continue to glow. The current is divided between them according to their resistance

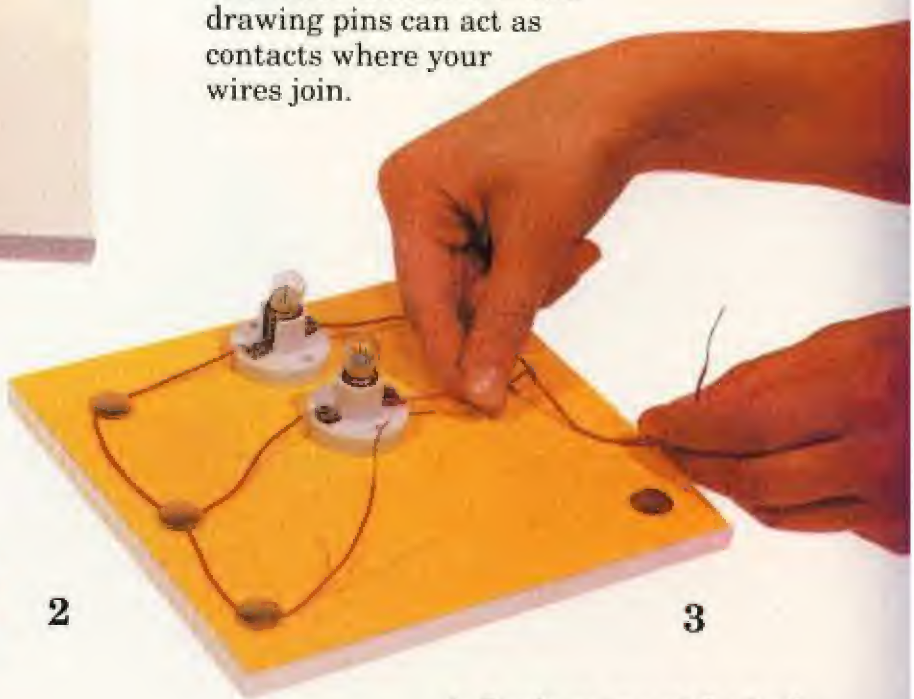
Lots Of Lights

1

1. You will need two large boards, drawing pins, insulated wire, bulbs, bulb-holders and batteries. The drawing pins can act as contacts where your wires join.

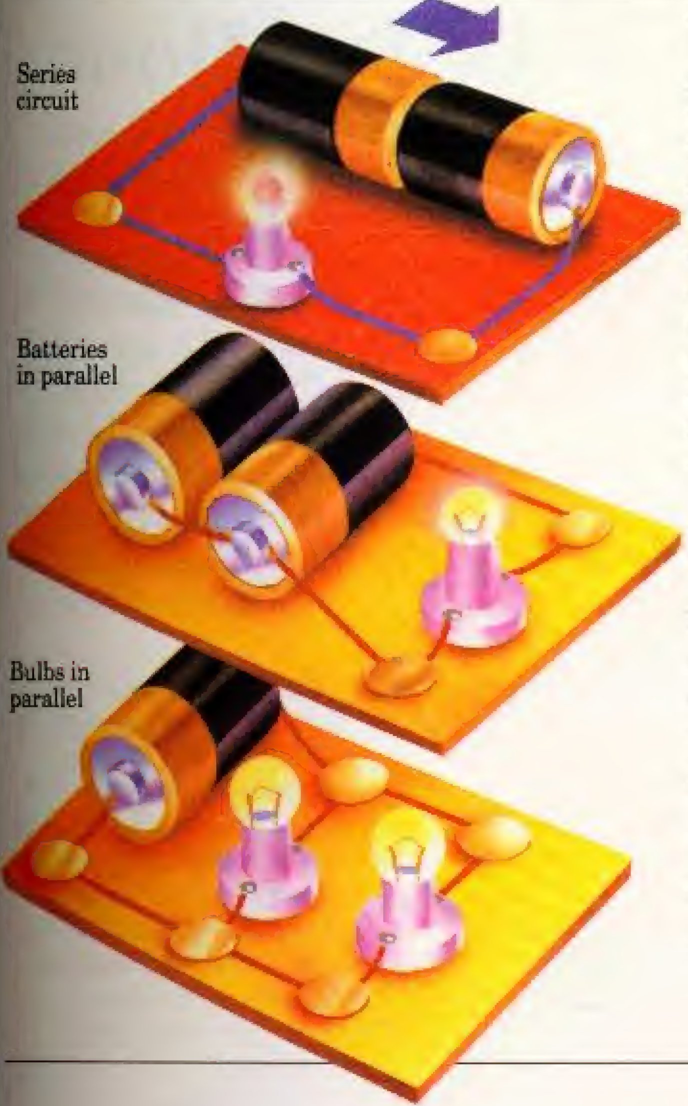
2. Set up your parallel circuit. If one bulb fails, the other will remain alight because the circuits are separate. Observe how brightly the bulbs glow.

2



3

3. Replace one of the bulbs in the parallel circuit with another battery. Does the light from the bulb change? Now wire up a series circuit like the red one shown here. Include one bulb and two batteries in this circuit.



Why It Works

A series circuit uses one path to connect the bulb and battery. If two batteries are used, the bulb glows twice as brightly as it would with one. Two bulbs in a series circuit would not glow as brightly as one. A parallel circuit provides more than one path for the current. Each bulb receives the same voltage (amount of power) even if another battery or bulb is added or removed. If two batteries are used in a parallel circuit, their power does not combine as in the series circuit. The bulb receives the voltage of one battery, but glows for double the time.

Bright Ideas

- Add another bulb to the series circuit. What do you notice when the current is switched on? Now add another one. What difference does this make? Draw a series circuit diagram.
- Wire another bulb into the parallel circuit. What do you notice about the glow from the bulbs? Draw a parallel circuit diagram.
- For how long do the bulbs in each kind of circuit stay alight? Which type of circuit is most wasteful of energy?

4

4. Observe this bulb. Dose it shine as brightly as the bulb in the yellow parallel circuit? Remove one battery. Which bulb is shining the brightest now?

Electricity In The Home

Modern houses contain parallel circuits called ring mains. One circuit is for the lighting, the other is the main circuit. Access to the main circuit is made possible through wall sockets. All household lights and appliances are connected in parallel, as this allows all devices to operate on the same voltage (level of power). This voltage will not change if a piece of equipment is added or taken away (see page 22). The current leaves the house through another wire. Faulty wiring may cause a fire in the home. To avoid such a risk, plugs and circuits are fitted with fuses. A fuse is a piece of wire which can easily melt, and so break a circuit, if the current is too high. A complex circuit, like that in a television set, has thousands of circuit parts. They consists of both parallel and series circuits. Make your own game using circuits and switches.

Turn Off The Light!

5. Now experiment with your circuit board. Can you light up only one bulb at a time by disconnecting certain switches? Now try lighting up two bulbs simultaneously. You can have hours of fun trying various connections. Observe the bulbs. When do they glow most brightly? When are they dimmest?

5

1. You will need a large board, three bulbs, three batteries, lengths of insulated wire, drawing pins, plasticine and paper clips.

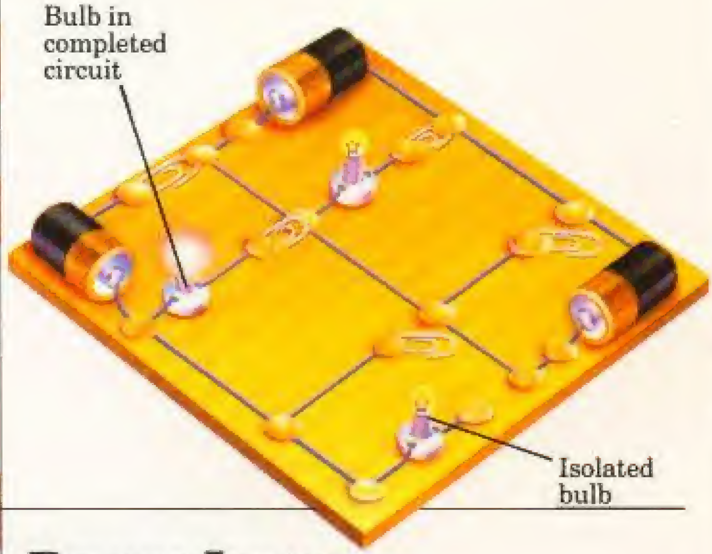
2. Place a battery in three corners of the board. Make sure that the unlike terminals are facing. Attach the wires using plasticine.

3. Connect the bulbs to the batteries as shown. Leave gaps in the circuits for switches. These can be paper clips and drawing pins.

4. Connect each switch by pressing down a paper clip on to a drawing pin. Observe the brightness of the bulbs. If any of the bulbs does not work, check all connections.

Why It Works

The flow of electrons is regulated by connecting and disconnecting the switches on the circuit board. When a bulb is isolated by disconnecting a switch, the circuit in which it is wired is broken. When every switch is connected, all the bulbs glow. The high resistance of a fuse restricts the amount of current that can pass through. Each appliance needs a fuse of the correct resistance.



Bright Ideas

Position the batteries so that the like terminals are facing each other. What effect does this have on your circuit board? Can the bulbs be lit up simultaneously now? Why is this? Remember that electrons travel from negative to positive. Do the bulbs glow just as brightly as before.

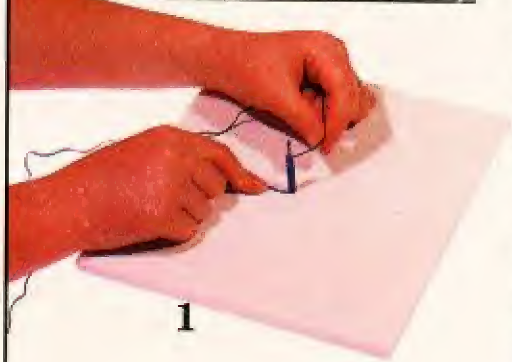
If you remove one bulb, how does this affect the circuits?

Ask an adult to show you where the electricity meter is located in your house. Keep a record of meter readings in your home for a week. Work out how much electricity has been used. Use your figures to make a graph. Count the number of sockets in your home. Make a list of all the electrical appliances used by your family. Watch the meter dials when each appliance is being used. Which uses the most electricity? Work out some ways in which your family could save electricity.

Electricity & Magnetism

Hans Oersted, a nineteenth century Danish scientist, first proved the relationship between electricity and magnetism. He noticed that a magnet held near to a compass caused it to turn. And when this experiment was repeated, replacing the magnet with a current of electricity, he observed the same effect. This was the beginning of electromagnetism. After Oersted's experiments, it was soon realised that magnets could be made by passing an electric current through coils of wire. A magnetic field (the region around the wire where the force of magnetism is felt) is created when we switch the current on and undone when we switch it off. When a doorbell is pressed, an electromagnet attracts a clapper to strike the bell. Use electromagnetism to hold the clown's nose in place.

Red Nose Day



1

1. Take a piece of thick board and push a nail through the centre. Now wind a piece of wire around the nail at least 20 times, leaving two ends of the same length.

2. Cut two triangular pieces of polystyrene to support the board in a sloping position.

2

3. Attach the triangles, as shown, and pierce a small hole in the side of one of them for a paper clip to fit through.

3

4. On a second sheet of polystyrene, draw a clown's face to fit on top of the shape you have made. Do not draw a nose on the face. Colour the face, then cut out your clown.

4

5. Fix a drawing pin to the side of a table tennis ball, coloured red. This will be your clown's nose. It will not fit in place yet.

5

6. Position the batteries inside the shape as shown. Make sure that the unlike terminals are touching each other. Now connect a wire from the nail to one end of the batteries using plasticine. Connect the other to the paper clip.

6

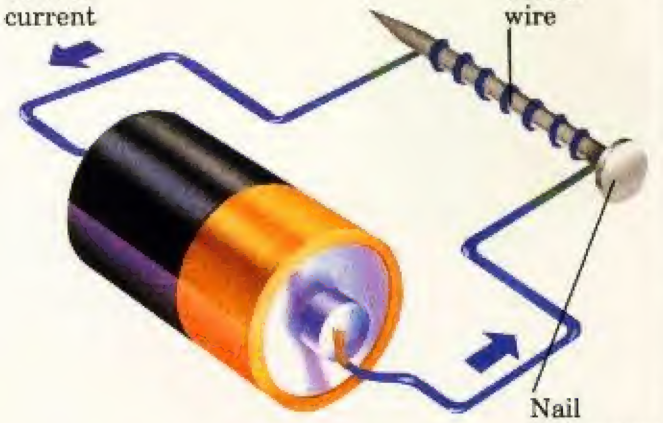
Bright Ideas

Reproduce Oersted's experiment.

Magnetize a needle and rest it on a piece of folded cardboard that is balancing on a stick. Place it in a jar–this will act as a compass. Now set up a simple circuit, allowing the wire to run above the magnetized needle. Observe the effect on the needle when the current flows. Wind more lengths of wire round your compass. What difference does this make?

Find out which appliances contain electromagnets. A telephone contains one.

Can you design a burglar alarm that works because of the effect of an elctromagnet?



Why It Works

When the current is switched on, the nail becomes a temporary magnet. The clown's nose stays in place, held in the magnetic field created by the electricity. When the electric current is turned off, the nail loses its magnetic properties and falls off.

7. Push the paper clip through the hole until it touches the adjacent battery terminal. Leave half of the paper clip protruding through the hole. Position the red nose on the clown's face.

7

8. When the paper clip is pushed inwards, the nose will stick to the clown's face. Now pull the paper clip outward's. The clown's nose will roll off his face.

8

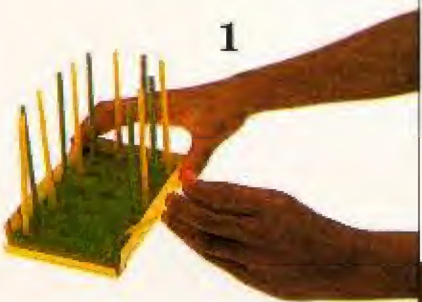
Electromagnetism

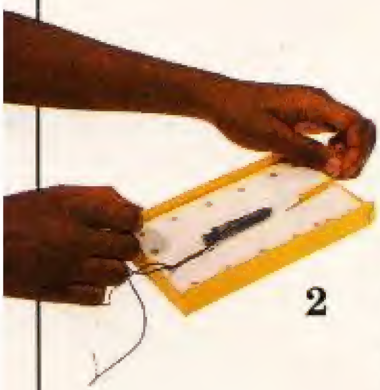
An English physicist, Michael Faraday, discovered that electrical energy could be turned into mechanical energy (movement) by using magnetism. He used a cylindrical coil of wire, called a solenoid, to create a simple electric motor. He later discovered that mechanical energy too can be converted into electrical energy–the reverse of the principle of the electric motor. His work led to the invention of dynamo. You can make a powerful electromagnet by passing electricity through a coil of wire wrapped many times around a nail (see page 26). Electromagnets are found in many everyday machines and gadgets. A body scanner, like the one shown here, contains many ring-shaped electromagnets. With a solenoid and a current of electricity, you can close the cage.

Caged!

1. Take a piece of polystyrene and edge it with cardboard. Stick plastic straws upright around three sides as the bars of the cage.

1





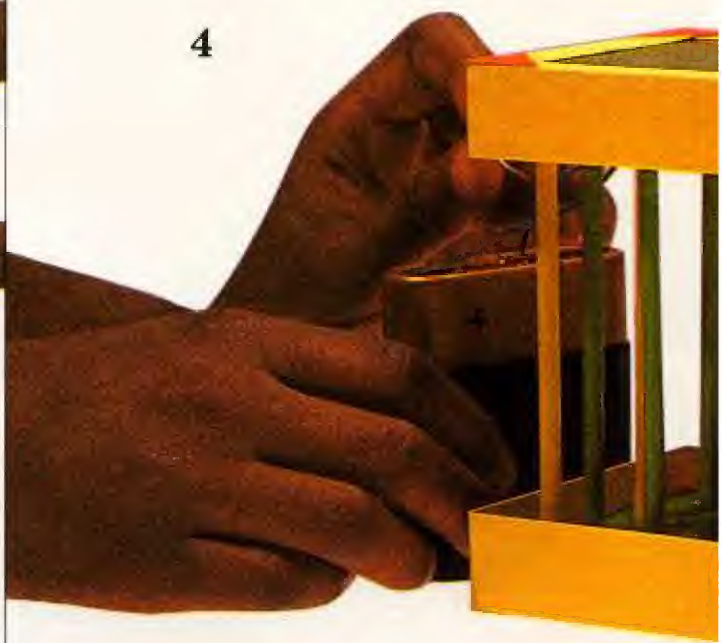
2

2. Cut out another piece of polystyrene of the same size for the roof of the cage. Fix a piece of plastic straw to the side above the door. Wind a piece of wire around a nail 50 times, leaving two ends free. Fix the nail to the roof, as shown.

3. Insert a needle into the straw so that it almost touches the nail. Cut out a rectangle of plastic for the door. Make a hole at the bottom of the door for the needle to fit through.

3

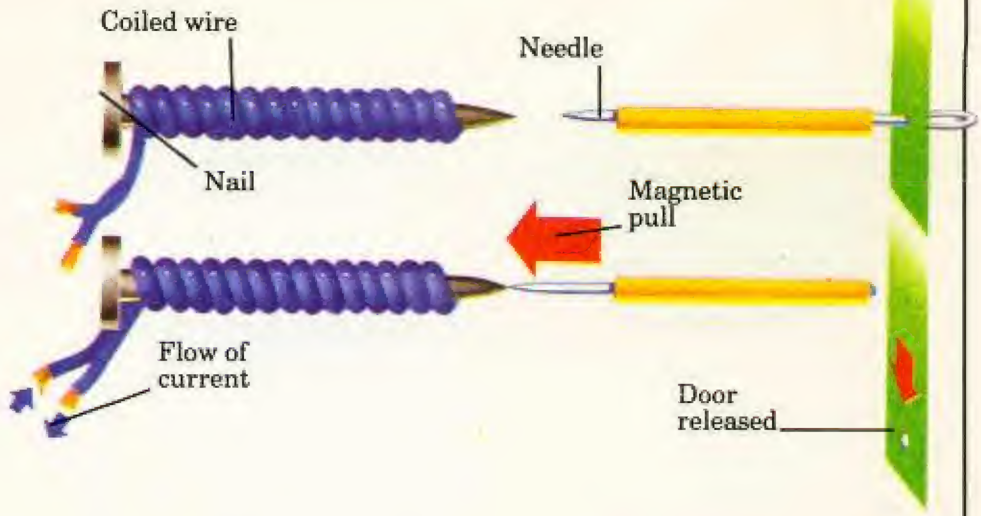
4



4. Stick a piece of card across the door to help hold it open, and make sure that the end of the needle just pokes through the hole. Now attach one of the wires to one terminal on the battery. Leave the other free. Make sure that it can reach the other terminal. Put the animal into the cage.

Why It Works

When the current is switched on, the nail becomes magnetized as the current flows through the wire. The needle in the door of the cage is attracted to the electromagnet. As the needle is pulled towards the nail, the door closes to trap the tiger.



Bright Ideas

- Wind more turns of wire on to the electromagnet. The magnetic effect will increase. What happens if you use a more powerful battery?
- Make another electromagnet using a shorter nail. This will also make the magnetic pull stronger.
- Make an electromagnetic pick-up by winding wire around a nail. What objects can you pick up? What happens when the current is turned off?
- Use an electromagnet to make a round-about work. Attach paper clips around the edge of a circular card lid to be the roof. Make sure that it is free to spin, and place an electromagnet close to the paper clips. The round-about should turns as you switch the current on and off quickly.

5. Now pick up the free wire. Allow the free wire to come into contact with the unconnected battery terminal. The needle should be pulled back towards the nail. The door will fall down, trapping the animal in its cage.

Electrolysis

Electrolysis is a process in which an electric current is passed through a liquid, causing a chemical reaction to take place. The liquid used is called the electrolyte. The wires or plates where the current enters or leaves the liquid are called electrodes. The electrolysis of metallic solutions is useful in putting metal coatings on objects. If you have a look at a car bumper, you will notice that it has a nice, smooth, metallic appearance. This is because car bumpers are coated with nickel in a process called electroplating. This helps to prevent the metal underneath from rusting. The same method is used to coat the cutlery with silver. This is called silverplating. Michael Faraday discovered the first law of electrolysis. The process is also used to purify metals like aluminium.

Copper-plating

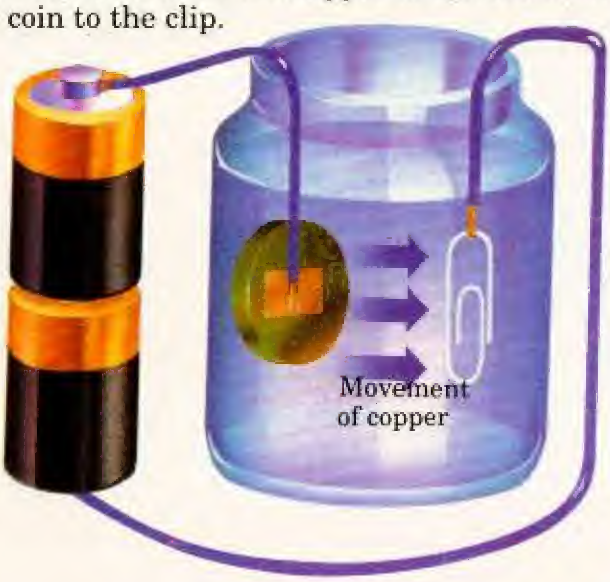
1. For this project you will need a glass jar, a copper coin, a paper clip, two batteries, insulated wire and water. Pour the water into the jar. Place the batteries together with unlike terminals adjacent. Connect wires to the terminals. Attach the copper coin to the wire from the positive terminal of the battery. The paper clip must be attached to the wire from the negative terminal. Use plasticine. Do not allow the metal objects to touch inside water. You could even tape each wire to the side of the jar so that they are suspended.

1

2. Observe closely what happens. Can you see bubbles? Leave them for a few minutes, then remove. Observe colour changes, if any. Replace them for a while. Are there any further changes? You will find that the copper coin becomes thinner.

Why It Works

The copper coin is connected to the positive terminal of the battery–the current enters here. The other, the paper clip, is joined to the negative terminal–the current leaves here. As the current flows through the water from the positive electrode (anode) to the negative electrode (cathode), the copper is carried from the coin to the clip.



Bright Ideas

Repeat the project using salt dissolved in vinegar instead of water. What difference do you notice, if any? What do you observe about the appearance of the paper clip? May be your school has scales that can weigh very small objects? If the coin and the paper clip are weighed before immersion in the liquid and their weight recorded, you can check whether electroplating has really taken place. After carrying out the project, weigh them both again. Now replace the battery with a more powerful one, or add a second battery into a parallel circuit, to increase the strength of the current passing through the liquid. Weigh the coin and paper clip a second time. If the weight of the paper clip has increased further, you have proved the first law of electrolysis that the amount of electric charge passed through the liquid determines the amount of copper freed.

2

Scientific Terms

ALTERNATING CURRENT An electric current that reverses its direction around a circuit at regular intervals.

DIRECT CURRENT An electric current that always flows in the same direction– like that produced in a battery.

EARTH WIRE A wire used as a safety precaution, connecting a piece of domestic apparatus to the ground. If the apparatus malfunctions, the 'live' objects is 'earthed'.

ELECTRIC CURRENT A continuous flow of electrons through a conductor; measured in amperes (amps).

ELECTRIC POWER The rate of transfer of electrical energy into another form of energy, such as light or heat; measured in watts.

ELECTRICAL RESISTANCE The degree to which materials obstruct the flow of an electric current; measured in ohms.

ELECTROLYTE A liquid in which a chemical reaction (electrolysis) takes place when an electric current is passed through it.

ELECTROMAGNETISM The relationship between electricity and magnetism. Either can be produced from the other.

INCANDESCENT LIGHT Light that results when a solid, like tungsten, is heate

MAINS ELECTRICITY Th electricity produced by electromagnetic induction. Produced at power stations, can reach almost every hom along power lines.

SHORT CIRCUIT A break power supply, due to a fault electrical connection, causin an electric current to take a path of low resistance.

VARIABLE RESISTOR (RHEOSTAT) A device to control the amount of electri city flowing through a circui

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